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RADIOGEOLOGY.—*Lead isotopes and the problem of geologic time.*[1]

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This paper seeks to point out a means of experimentally measuring the lead which has been actually produced by the radioactive disintegration of uranium alone, and thereby to provide definite figures for the uranium-lead ratio in its application to the determination of geologic time.

Of the various methods which have been tried or suggested for obtaining a more or less accurate estimate in terms of years of geologic time, that one which uses the uranium-lead ratio is by far the most promising and the most definite. This method is based upon the fact that uranium and thorium are the original elements which produce, by spontaneous disintegration, the long series of radioactive substances which undergo radioactive changes one into the other until finally they produce in each case lead. This lead appears to have no further radioactivity[2] and is assumed to be the final and end product of these radioactive changes.

The time required for these changes to take place has been accurately determined in the case of the uranium series and with much less accuracy for the thorium series, so that we now know just how many years are required for a given amount of uranium to change into its corresponding amount of lead.

It would seem, therefore, that all that is needed to determine the age of a mineral containing considerable amounts of uranium or thorium or both, together with their corresponding lead, would be a careful

[1] Received April 19, 1928.

[2] However, the term "radioactive lead" has come into the literature, and signifies that lead which is known to have been produced by radioactive means.

chemical analysis to determine the amounts of these various constituents, and the substitution of the figures obtained in a suitable formula.

However, as is usually the case, the actual practice is not so simple as the theory would indicate. The necessary chemical analysis is exceedingly difficult and tedious, and the amounts of the significant elements obtained are so small that minute analytical errors have disproportionately great effects upon the ultimate result. The extrapolation in terms of years over vast geologic ages is so great that legitimate analytical errors may cause a difference of hundreds of thousands of years in the indicated age.

This aspect of the problem must depend upon the completeness of the analytical separations and upon the care and skill of the analyst.

But the chemical analysis alone, however satisfactory it may be as a mineral analysis, cannot show whether or not the lead obtained is all of radioactive origin, or whether it came partly from uranium, partly from thorium, or partly from some other source.

The possibility of enrichment by lead from some non-radioactive source must be considered, and also the partial removal of the lead already radioactively produced. These considerations, however, are outside the scope of this paper.

But assuming that the above requirements have all been satisfactorily met, there yet remain two grave uncertainties which make this method unsound and unsatisfactory in its application. They are the most troublesome uncertainties inherent in this procedure and as yet there has been no direct experimental method for dealing with them. They are:

(1) The uncertainty associated with the disintegration of the thorium series—the time required and the amount and origin of the lead produced.

The thorium series of radioactive disintegrations has not yielded to experimental examination as readily as the uranium series has. Consequently there is considerable uncertainty associated with the time required for a given amount of thorium to form its corresponding amount of lead. Also the quantity of lead produced by a given quantity of thorium is not known with satisfactory accuracy.

Therefore the presence of thorium in a mineral to be used for an age determination injects a considerable element of uncertainty into the result, and as some thorium is always present this cannot be avoided. The formula now used contains a corrective factor to take care of the thorium content, but it is admittedly unsatisfactory.

(2) The fact that there is no actual measure of that proportion of the total lead which is known to have been produced from the uranium alone.

If this latter could be determined by actual experimental measurement the thorium uncertainty could be disregarded and the only other uncertainty which would remain inherent and unmeasured in this method would be the existence of possible isotopes of uranium which might have disintegrated more rapidly in the past than the uranium which we know today.

If the lead in any given mineral being studied could be obtained in sufficient quantity and converted into some compound capable of giving lines in the mass-spectrograph, and if the intensity of these lines could be accurately measured, we would then have a direct experimental method for determining the actual amount of uranium lead present. The position of the line would identify it with the uranium-lead isotope and its relative intensity would furnish a measure of its relative amount, and since the actual weights of uranium and lead would be known from the chemical analysis we would then have all the information necessary for a direct comparison of the amounts of uranium and uranium-derived lead. Any other isotopes of lead could be disregarded and no reliance need be placed upon assumed proportions figured from atomic weight determinations of lead associated with uranium and thorium, while any enrichment by ordinary lead would probably be revealed by an abnormally intense "207 line."

It was with these considerations in mind that the author, in October, 1926, wrote to Dr. F. W. Aston, F.R.S., and requested his criticism and coöperation in a proposed plan to convert samples of lead into some volatile organic compound such as lead tetramethyl, lead tetraethyl, lead phenyl, etc., and to endeavor to secure with it the identification and determination of any isotopes by means of the mass-spectrograph. After some correspondence it was decided that lead tetramethyl was the most promising material, and that the first efforts should be directed toward a separation and identification of the isotopes of ordinary laboratory lead.

For this purpose the author took a sample[3] of lead tetramethyl to Dr. Aston in July, 1927, and shortly thereafter Dr. Aston carried out several experiments with this material. The results were most

[3] Prepared for him by Mr. S. C. WITHERSPOON of the U. S. Chemical Warfare Service.

satisfactory and were first published by Dr. Aston in a brief note to *Nature* dated July 30, 1927.[4]

The experiments demonstrated very clearly the existence of the three anticipated isotopes, namely, those of masses 206, 207, and 208 in the approximate ratios of 4, 3, and 7 respectively, and also revealed the existence of other isotopes of lead, present in very small proportions, of which 203, 204, and 205 were indicated, and 209 was reasonably certain.

The isotopes having been thus definitely separated and identified, the next step was to do the same for "radioactive lead," i.e., lead which had been formed mostly or entirely by the radioactive disintegration of uranium and thorium.

For this purpose the author secured some very pure Norwegian bröggerite, a mineral which contains considerable proportions of uranium and lead but a very small proportion of thorium. This material was carefully analyzed[5] for uranium, thorium, and lead and a sufficient quantity "worked up" to yield about 15 grams of "radioactive lead" chloride.

Five grams of this material was converted into lead tetramethyl[6] and sent in a sealed tube to Dr. Aston. Unfortunately, this tube was broken in transit and the material lost, but another quantity of radioactive lead tetramethyl has been prepared and it is proposed to try this in the mass-spectrograph this summer.

Meanwhile Dr. Aston has been developing an instrument for accurately measuring the relative intensities of the lines on the photographic plates from his mass-spectrograph. This will eliminate the personal equation from this determination and render it capable of exact repetition and comparison.

Since there is very little thorium, relative to uranium, in this bröggerite it is anticipated that these next experiments will show a very heavy line at 206, a very light one at 208, and possibly none at all at 207. It will be interesting to see whether any of the other isotopes show up stronger from this radioactive lead than they did with the ordinary lead tetramethyl.

From the data obtained from these two series of lead-isotope measurements we hope to be able:

[4] Nature **120**: 224. 1927.

[5] By Dr. C. N. Fenner of the Geophysical Laboratory.

[6] See note 3.

(1) To determine directly the uranium:uranium-lead ratio for this sample of bröggerite and thereby secure a reliable estimate of its age.
(2) To determine definitely the thorium:thorium-lead relationships.
(3) To throw some light on the other isotopes of lead and their origin.

BOTANY.—*New plants from Central America.*—XIII.[1] PAUL C. STANDLEY, U. S. National Museum.

The Central American plants here proposed as new belong to the family Rubiaceae. Seven of them are representatives of the vast genus *Psychotria*. Formerly it was believed that this group was poorly represented in Central America, but continued exploration suggests that the Central American species may finally equal in number those known from the Antilles.

Psychotria Alfaroana Standl., sp. nov.

Erect shrub 30–60 cm. high, usually simple but sometimes with a few short branches above, the stems terete or obtusely quadrangular, the internodes mostly short, about 1 cm. long, or sometime elongate; stipules deciduous, 8–18 mm. long, often ciliate, the base oblong-ovate, deeply cleft to below the middle, the lobes linear, long-attenuate; leaves opposite, the petioles 1–2 cm. long, stout, often marginate nearly to the base; leaf blades obovate-oblong to elliptic, 11.5–26 cm. long, 3.5–9 cm. wide, acute or abruptly acute, usually long-attenuate to the petiole and decurrent, sometimes merely acutely cuneate at base, thick-membranaceous, deep green above (often glaucescent when dry), glabrous, usually marked on both surfaces with numerous short linear raphids, beneath somewhat paler, often minutely puberulent on the nerves, at least when very young, but soon glabrate, the costa stout, prominent, the lateral nerves slender, about 13 on each side, divergent at a wide angle, arcuate, anastomosing rather remote from the margin, the intermediate nerves inconspicuous; inflorescence terminal, cymose-umbellate, the primary peduncles several, 4–7 mm. long, sordid-puberulent or glabrate, each bearing few or numerous flowers, these borne on stout puberulent pedicels 2–4 mm. long (in fruit); whole inflorescence compact, subglobose, in fruit 2–4.5 cm. broad, borne on a stout erect peduncle 1.5–3.5 cm. long; bracts deciduous; fruit at maturity red, ellipsoid, 8–10 mm. long, 5–6 mm. thick, glabrous; pyrenes 2, sharply 3 or 4-costate dorsally, plane on the inner surface.

Type in the U. S. National Herbarium, no. 1,253,966, collected in wet forest at El Arenal, Province of Guanacaste, Costa Rica, altitude 500 meters,

[1] Published by permission of the Secretary of the Smithsonian Institution. For the last preceding paper of this series see this JOURNAL **18**: 178. 1928. Received December 27, 1927.

January 18, 1926, by Paul C. Standley and Juvenal Valerio (no. 45179). The following collections are referable here:

COSTA RICA: El Arenal, *Valerio* 62, *Standley & Valerio* 45200. El Silencio, Guanacaste, alt. 750 m., *Standley & Valerio* 44585, 44620, 44603, 44771. Los Ayotes, near Tilarán, Guanacaste, alt. 700 m., *Standley & Valerio* 45359. La Tejona, near Tilarán, Guanacaste, alt. 600 m., *Standley & Valerio* 45845, 45855. Pejivalle, Prov. Cartago, alt. 900 m., *Standley & Valerio* 46985.

The species is named for Don Anastasio Alfaro. It is an unusually well marked *Psychotria*, easily recognized by its dwarf habit and condensed globose inflorescence.

Psychotria haematocarpa Standl., sp. nov.

Shrub 1–2.5 m. high, the branches slender, terete or the younger ones obtusely quadrangular, glabrous, the internodes mostly about 1 cm. long but often much longer; stipules persistent, green, united to form a very short sheath, this bicuspidate on each side, the cusps linear-filiform, 3–4 mm. long, glabrous; leaves opposite, the petioles slender or stout, 3–8 mm. long, not sharply differentiated from the blade, glabrous or sparsely puberulent; leaf blades oblong-elliptic, broadest at the middle, 8.5–14 cm. long, 2.5–5 cm. wide, abruptly or gradually long-acuminate, with narrow, often falcate, attenuate-acute acumen, at base gradually or abruptly acute or attenuate and decurrent upon the petiole, membranaceous, glabrous, somewhat lustrous, deep green above, the costa prominent, beneath slightly paler, the costa and lateral nerves slender, prominent, the lateral nerves about 9 on each side, divergent at a very broad angle, slightly curved, irregularly anastomosing remote from margin, pale, the intermediate nerves prominulous, laxly reticulate, the margins plane; inflorescences terminal, capitate, dense, few-flowered, the peduncles 3–4 mm. long, green, puberulent or glabrate; outer bracts lance-linear, acute, green, glabrous, 1.5–2 mm. long; flowers sessile or nearly so; fruit globose, bright red, glabrous, 5 mm. long; pyrenes obtusely 5-costate dorsally, the inner surface plane, not grooved.

Type in the U. S. National Herbarium, no. 1,254,627, collected in moist forest at Naranjos Agrios, near Tilarán, Guanacaste, Costa Rica, altitude 600 to 700 meters, January 29, 1926, by Paul C. Standley and Juvenal Valerio (no. 46407). One other collection is referred here:

COSTA RICA: Pejivalle, Prov. Cartago, alt. 900 m., *Standley & Valerio* 47194.

The relationship of this plant is evidently with *P. involucrata* Swartz, a species widely dispersed in tropical America. The latter differs in the strongly ascending nerves of the leaves, and in the ample, usually branched inflorescence with large bracts.

Psychotria sylvivaga Standl., sp. nov.

Shrub 1–3 m. high, the branches stout, the older ones brownish, obtusely quadrangular, the young branches minutely puberulent or glabrate, 1.5-4 cm. long; stipules distinct, caducous, broadly ovate, 8–10 mm. long, thin, brown, glabrous, marked with numerous short linear raphids; leaves opposite, the petioles slender or stout, 0.8–2.5 cm. long, glabrous; leaf blades oblong-oblanceolate or rarely elliptic-oblong, nearly always broadest above the

middle, 9–17 cm. long, 2.5–5.5 cm. wide, usually abruptly acuminate or short-acuminate, with obtuse tip, gradually long-attenuate to the base and decurrent, thick-papyraceous, deep green above, lustrous when fresh, glabrous, narrowly sulcate along the costa, beneath slightly paler, usually sparsely and obscurely short-barbate in the axils of the lateral nerves, the costa and lateral nerves slender, prominent, the lateral nerves 11–16 on each side, divergent at a wide angle, arcuate, irregularly and laxly anastomosing near the margin, the intermediate nerves obscure; inflorescence terminal, cymose-paniculate, lax, many-flowered, the peduncle 5.5–7 cm. long, erect; panicles 4.5–9.5 cm. long, 5.5–11 cm. wide, the primary branches opposite, divaricate, minutely puberulent, the terminal cymes few-flowered, umbelliform, the pedicels in anthesis 1–3 mm. long, puberulent, in fruit sometimes 8 mm. long; bracts minute, triangular, green, brown-ciliate, caducous, their scars brown-pilose; hypanthium globose-turbinate, 1–1.5 mm. long, minutely puberulent; calyx 1 mm. long, shallowly 5-dentate or subtruncate, the teeth broadly triangular, green, obtuse, minutely ciliolate; corolla salverform greenish white, glabrous, the tube 5 mm. long, 1.2 mm. thick, the lobes triangular-ovate, 1.5 mm. long, obtuse; fruit green, globose, 5-6 mm. long, glabrous; pyrenes 2, obtusely 5-costate dorsally, plane on the inner surface, the seeds not grooved.

Type in the U. S. National Herbarium, no. 1,306,274, collected in wet forest at Yerba Buena, northeast of San Isidro, Province of Heredia, Costa Rica, altitude 2,000 meters, February 28, 1926, by Paul C. Standley and Juvenal Valerio (no. 49989). The following collections are conspecific:

COSTA RICA: Wet oak and bamboo forest near Laguna de la Escuadra, northeast of El Copey, Prov. San José, alt. 2,200 m., *Standley* 41974, 41924. Laguna de la Chonta, northeast of Santa María de Dota, Prov. San José, alt. 2,000 m., *Standley* 42212.

Psychotria chiriquina Standl. differs from the present plant in its smaller leaves, glabrous inflorescence, and short corolla. *P. Jimenezii* Standl., which also is related, has nearly sessile leaves, a short corolla, and more evidently pubescent inflorescence.

Psychotria eurycarpa Standl., sp. nov.

Shrub or small tree, 2.5–5 m. high, the branches stout, green, glabrous, the internodes 1–8 cm. long; stipules persistent, green, glabrous, forming an intrapetiolar ring 1–2 mm. long, this cuspidate between the petioles, the cusp subulate, 1–2.5 mm. long; leaves opposite, the petioles stout, 4–18 mm. long, glabrous; leaf blades chiefly elliptic or broadly elliptic, rarely oblong-elliptic, broadest at the middle, 7.5–15.5 cm. long, 2.5–9 cm. wide (averaging about 9.5 by 4.5 cm.), abruptly acuminate or short-acuminate, with acuminate tip, sometimes rounded at apex and short-cuspidate, at base varying from acute to narrowly rounded, sometimes short-decurrent, papyraceous to thin-coriaceous, glabrous, deep green and lustrous above, the costa elevated, beneath paler, lustrous, the costa and lateral nerves rather stout, pale, prominent, the lateral nerves 6 or 7 on each side, divergent at a wide angle, strongly arcuate and directed upward, extending nearly to the margin and there irregularly anastomosing, the intermediate nerves prominulous, pale, coarsely reticulate; inflorescences terminal, cymose-paniculate, the peduncle 0.7–3 cm. long, stout, erect; panicles corymbiform, 2–3 cm. long, usually broader than long, the primary branches green, compressed, glabrous or minutely pulverulent, divaricate or usually ascending, densely few-flowered, the

flowers sessile; bracts persistent, green, inconspicuous, linear to triangular, 1–2 mm. long; hypanthium globose-turbinate, 1 mm. long, pulverulent; calyx 0.8 mm. long, shallowly 5-dentate or subtruncate, the teeth broadly triangular, broader than long, green; corolla in bud 4–6 mm. long, pulverulent; fruit at first green, at maturity blue-black, subglobose, 9–12 mm. long, glabrous, shallowly bisulcate; pyrenes 2, sharply 5-sulcate dorsally, deeply and narrowly sulcate on the flat inner surface from base to apex.

Type in the U. S. National Herbarium, no. 1,254,544, collected in moist forest at Quebrada Serena, southeast of Tilarán, Guanacaste, Costa Rica, altitude about 700 meters, January 27, 1926, by Paul C. Standley and Juvenal Valerio (no. 46237). As representative of the species may be listed several other collections:

Costa Rica: Forests of San Pedro, near San Ramón, alt. 1,300–1,400 m., *Tonduz* 17657. Finca Montecristo, near El Cairo, Prov. Limón, *Standley & Valerio* 48435. El Arenal, Guanacaste, *Valerio* 98.

The species is well marked by the unusually large fruit.

Psychotria orchidearum Standl., sp. nov.

Small erect epiphytic shrub 15–30 cm. high, glabrous throughout; older branches stout, 3–4 mm. thick, ochraceous, rimose, the younger ones quadrangular, ochraceous, lustrous, the internodes mostly 3–6 mm. long; stipules intrastipular, forming an indurate truncate sheath 1–2 mm. long; leaves opposite, the petioles slender, 2–4 mm. long, or often nearly obsolete; leaf blades elliptic or oblong-elliptic, 15–32 mm. long, 6–12 mm. wide, obtuse or acute, apiculate, usually cuneate-acute or attenuate at base, rarely obtuse, thick and fleshy, deep green above, the venation obsolete, beneath paler, the costa evident but the other nerves obsolete; inflorescence terminal, cymose-paniculate, lax, few-flowered, the peduncle slender, 10–13 mm. long, erect, the panicles 1.5 cm. long and broad or smaller, the branches very slender; bracts persistent, greenish, linear or linear-subulate, 1–3 mm. long; pedicels slender, mostly 3–5 mm. long; hypanthium obovoid, 1 mm. long; calyx 1 mm. long, 4-dentate to the middle, the teeth triangular, acute; fruit subglobose, 3 mm. long, red, shallowly bisulcate laterally; pyrenes 2, smooth dorsally, the inner face slightly concave, deeply and narrowly sulcate from base to apex.

Type in the U. S. National Herbarium, no. 1,306,503, collected on tree in wet forest on Cerros de Zurquí, northeast of San Isidro, Province of Heredia, Costa Rica, altitude about 2,200 meters, March 3, 1926, by Paul C. Standley and Juvenal Valerio (no. 50863). No. 50757, from the same locality, represents the same species.

Psychotria orchidearum is closely related to *P. Maxonii* Standl., a common plant of the same region. *P. Maxonii* has long slender branches and is usually a larger plant; its leaves are much narrower than those of *P. orchidearum*, being chiefly linear-lanceolate.

Psychotria grandistipula Standl., sp. nov.

Shrub 3 m. high, the branches slender, subterete, green, very minutely puberulent, the internodes 1.5–4.5 cm. long; stipule one at each node, caducous, forming a sheath about the young leaves, cleft on one side, 3–4.5 cm. long, long-attenuate to a subulate apex, thin, brown, glabrous; leaves opposite, the petioles slender, 1.5–4 cm. long, minutely puberulent; leaf blades

lance-oblong to oblong-ovate or elliptic, 5.5–14 cm. long, 2.2–6 cm. wide, abruptly long-acuminate or cuspidate-acuminate, with attentuate acute tip, at base usually very obtuse to truncate but sometimes (even on the same branch) acute, thick-membranaceous, deep green on the upper surface, glabrous, the venation not elevated, beneath scarcely paler, minutely puberulent on the nerves, the costa and lateral nerves slender, elevated, the lateral nerves 9–14 on each side, ascending or the lowest divaricate, slightly arcuate, extending nearly to the margin, there laxly and irregularly anastomosing, the intermediate nerves obsolete; inflorescences terminal, sometimes appearing lateral by the continued growth of the main axis, cymose-paniculate, usually sessile, 4–13 cm. long, lax, many-flowered, the branches slender, minutely puberulent, divaricate or ascending; bracts caducous; pedicels 3–12 mm. long, straight, minutely puberulent; calyx persistent on the fruit, less than 1 mm. long, shallowly and remotely 5-dentate; fruit subglobose, bright red, 7 mm. long, glabrous; pyrenes 2, obtusely 5-costate dorsally; seeds narrowly sulcate on the inner surface from base to apex.

Type in the U. S. National Herbarium, no. 1,253,164, collected in moist forest near Santa María de Dota, Province of San José, Costa Rica, altitude about 1,600 meters, December 26, 1925, by Paul C. Standley and Juvenal Valerio (no. 43268). Additional collections are at hand, as follows:

Costa Rica: Santa María, *Standley* 42402, 41806; *Standley & Valerio* 43187, 44098. La Colombiana Farm, Prov. Limón, alt. 70 m., *Standley* 36871.

The last specimen cited has no stipules and may not belong here, although it does not appear to differ essentially in other respects from the collections made at Santa María. It is rather unusual to find in the wet coastal forest a species that grows in such a high and comparatively dry region as that of Santa María.

Psychotria grandistipula is unique among the Costa Rican species of the genus in its exceptionally developed stipules.

Palicourea vestita Standl., sp. nov.

Shrub 1.5–2.5 m. high, the branches slender or stout, subterete, densely villous with short slender spreading yellowish many-celled hairs, the internodes 1.5–7.5 cm. long; stipules persistent, green, united to form a sheath 5 mm. long, this truncate, densely short-villous, bicuspidate on each side, the cusps linear, erect, 5–7 mm. long, stiff, attenuate to the apex, puberulent; leaves opposite, the petioles stout, 1.5–3 cm. long, densely short-villous or tomentulose; leaf blades lance-oblong, broadest at or sometimes slightly above the middle, 10–18 cm. long, 2.5–6 cm. wide, rather abruptly acuminate or long-acuminate, with narrow acute tip, narrowed to the acute or obtuse base, thick-membranaceous, bright green above, short-villous along the costa, beneath slightly paler, densely villous on the nerves with short slender yellowish spreading hairs, elsewhere velutinous-pubescent or sometimes glabrate, the costa stout, elevated, the lateral nerves slender, prominent, about 20 on each side, arcuate-divaricate, irregularly anastomosing close to the margin; inflorescence terminal, cymose-paniculate, many-flowered, narrowly pyramidal, 7–9 cm. long, the peduncle stout, 2.5 cm. long, the branches stout, reddish green, divaricate at right angles, densely pubescent; bracts green, linear, 2–4 mm. long; pedicels 2–5 mm. long, stiff, hirtellous; calyx lobes 5, persistent on the fruit, 1 mm. long, triangular, acute, hirtellous;

fruit blue, obovoid-globose, 5 mm. long, slightly compressed laterally and bisulcate, hirtellous; pyrenes 2, each with 3 broad rounded dorsal costae.

Type in the U. S. National Herbarium, no. 1,253,015, collected in wet oak forest near Quebradillas, about 7 km. north of Santa María de Dota, Prov. San José, Costa Rica, altitude about 1,800 meters, December 24, 1925, by Paul C. Standley (no. 42909).

Among the Costa Rican species of *Palicourea* this may be recognized by the copious pubescence of all parts, and by the numerous lateral nerves of the leaves.

Palicourea macrocalyx Standl., sp. nov.

Shrub 2 m. high, glabrous throughout, the young branches green, subterete, the internodes 2.5–4.5 cm. long; stipules green, persistent, 6–9 mm. long, cleft nearly to the base, the lobes triangular-oblong, 2–3 mm. wide, attenuate to the acute apex; petioles slender, 2–2.5 cm. long; leaf blades elliptic-oblong, 8–12 cm. long, 3.3–5 cm. wide, abruptly short-acuminate, with obtuse tip, at base broadly obtuse to acutish, subcoriaceous, somewhat lustrous, the costa and lateral nerves prominent on both surfaces, the costa stout, the lateral nerves about 14 on each side, divaricate, strongly arcuate, extending nearly or quite to the margin, the intermediate nerves prominulous, reticulate; inflorescence terminal, cymose-paniculate, much branched, dense, many-flowered, about 6 cm. long and broad, the peduncle 5 cm. long, the branches dark purplish; bracts oblong to broadly ovate, 4–5 mm. long, green, obtuse or rounded at apex; pedicels 4–6 mm. long, jointed at apex; hypanthium turbinate, 2 mm. long; calyx 5 mm. long, pale yellow, 5-lobate nearly to base, the lobes ovate, narrowed to the obtuse apex, conspicuously 3-nerved; corolla pale yellow, the tube 9 mm. long, 1.5 mm. thick, the 5 lobes broadly triangular-ovate, 2–5 mm. long, obtuse, spreading.

Type in the U. S. National Herbarium, no. 1,306,801, collected in wet forest on Cerro de las Lajas, north of San Isidro, Province of Heredia, Costa Rica, altitude about 2,200 meters, March 7, 1926, by Paul C. Standley and Juvenal Valerio (no. 51611).

Among the Central American species of *Palicourea* this may be recognized easily by the unusual development of the calyx.

Palicourea pauciflora Standl., sp. nov.

Shrub or small tree, the branches green, the older ones terete, the young ones obtusely quadrangular, the internodes 1–3.5 cm. long, densely and minutely puberulous; stipules 4–5 mm. long, green, persistent, distinct or nearly so, bilobate nearly to the base, the lobes narrowly triangular, narrowed to the obtuse apex, minutely puberulous; petioles slender, 5–15 mm. long, puberulent; leaf blades elliptic-oblong, 4–7 cm. long, 1–2.2 cm. wide, abruptly cuspidate-acuminate, the acumen 8–13 mm. long, narrow, acute, at base acute or attenuate, subcoriaceous, deep green above, glabrous, dull, the venation inconspicuous, beneath paler, minutely puberulous, the costa slender, salient, the lateral nerves very slender, prominulous, about 10 on each side, ascending at a wide angle, arcuate, extending nearly or quite to the margin, the intermediate nerves obsolete; inflorescence terminal, cymose-paniculate, open, sparsely branched, few-flowered, short-pedunculate, 4–5 cm. long and broad, the branches puberulent; bracts lance-oblong, green, 3–4 mm. long; pedicels 3–7 mm. long, glabrous, jointed at apex; hypanthium obovoid, 2–2.5 mm. long,